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Biomimicking: Electro-Elastic Structural Speciality in Auditory Receptor Cells

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13. ABSTRACT *(Maximum 200 words)*

A recent discovery is that certain receptor cells in the cochlea in the inner ear undergo displacement due to an electric field, for frequencies as high as 25 kHz in the guinea pig. In the hearing process, these cells are likely to provide the important feedback mechanism for the enhancement of low amplitude sound. Part is due to the unique microstructural design of the wall of the cell, consisting of a passive elastic cytoskeleton and an isotropic piezoelectric membrane. Using measurements from several laboratories permitted the calculation of the orthotropic piezoelectric properties of the wall. With our measurements, the elastic moduli of the protein components in the cytoskeleton were determined. Computations of the dynamic response of the whole cell containing and immersed in a viscous fluid agree fairly well with experiments. Despite the small cell size, small in comparison with the viscous boundary layer, the orthotropic design permits the cell to delivery significant force with low electric signal at auditory frequencies. Possible application of the design to devices is being pursued.

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REF: Biomimicking: Electro-Elastic Structural Speciality in Auditory Receptor Cells
F49620-92-J-00276 Period: 05/15/92- 05/14/95

September 16, 1995

Dear Dr. Jones,

In response to your Fax, dated 14 September 1995, I am enclosing three additional copies of the one-page final report on this project along with the completed Form 298.

Sincerely yours,

Charles R. Steele
Professor of Applied Mechanics

REF: Biomimicking: Electro-Elastic Structural Speciality in Auditory Receptor Cells
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A. Researchers working on contract/grant

Faculty: Charles R. Steele, PI, Professor, Mech. Eng., Stanford University
Postdocs: None
Graduate Students: Tolomeo, Jason, Doctorial Candidate, Mech. Eng., US citizen
Zetes, Deborah E., Doctorial Candidate, Mech. Eng., US citizen
Other Gary Baker, Doctorial Candidate Mech. Eng., US citizen
(Work closely related to project, supported under NIH)

B. Articles in peer-reviewed publications

J.A. Tolomeo and C.R. Steele (1995). "Orthotropic piezoelectric properties of the cochlear outer hair cell wall", *J. Acous. Soc. Am.*, 95 (5), 3006-3011.

Other publications:

C.R. Steele and G. Baker (1993). "Hydroelastic waves in the cochlea", in Proceedings, Symposium in Honor of Holt Ashley, Stanford University.

C.R. Steele, G. Baker, J. Tolomeo, and D. Zetes (1995). "Cochlear Mechanics", in *Biomechanics Section*, D.J. Schneck, assoc. ed., *CRC Biomedical Engineering Handbook*, CRC Press, Boca Raton.

C.R. Steele (1995). "Three-dimensional computation of the cochlea", Proceedings of the British Physiological Society, Meeting in Keele, England.

In review:

G. Baker and C.R. Steele (1995). "Feedforward of energy in waves on the cochlear partition", submitted for publication.

J.A. Tolomeo, M. Holley, and C.R. Steele (1995). "Mechanical properties of the cochlear outer hair cell wall", submitted for publication.

D.N. Furness, D.E. Zetes, C.M. Hackney, and C.R. Steele (1995). "Kinematic analysis of shear displacement as a means for operating mechanotransduction channels in the contact region between adjacent stereocilia of mammalian cochlear hair cells", submitted for publication.

Not directly related to project:

Yeh-Liang Hsu, Charles R. Steele, and Sheri D. Sheppard (1994). "Fully stressed thickness profile design at discontinuities of axisymmetric shells", *Structural Optimization*, 7(3), 199-205.

S. Roberts, T.M. Hutchinson, S.B. Arnaud, B.J. Kiratli, R.B. Martin , C.R. Steele (1994). "Non-Invasive determination of bone mechanical properties using vibration response: a refined model and validation *in vivo*", *J. Biomechanics*, in press.

Y.-C. Fu and C.R. Steele (1995). "Fourier series solution for the Dugdale crack in a cylindrical shell", *J. Appl. Mech.*, 62(2) 533-535.

C.R. Steele, J.A. Tolomeo, and D.E. Zetes, (1995). "Shell Analysis", in *Handbook of Shock and Vibration Computer Programs.*, W.D. Pilkey, ed., in press.

C.R. Steele, J.A. Tolomeo, and D.E. Zetes, (1995). "Dynamic Analysis of Shells", *Journal of Shock and Vibration* , in press.

C. Honors and Awards

In this time period:
Elected member American Academy of Engineering, 1995.
From Germany, Humboldt Senior Fellowship Award, 1994.
Prior: Fellow, ASME 1980
Citation: PVP Division of ASME 1982
Fellow, Amer. Acad. Mech. 1985
Citation: NASA 1987
NIH Claude Pepper Award 1988.
President, Amer. Acad. Mech. 1989-90